signal from the mixers 116, 127, 128 are passed through respective low pass filters 117, 129, 130 and error amplifiers 118, 131, 132 to provide error signals representing the difference between the phase of the received signal at each coil and the reference phase. The error signals are applied to the phase shifters 120, 121, 122 to adjust the phases of each of the received signals to maintain the phase coincidence for summing. As in the prior embodiment, the phase adjusted signals are combined by the summing amplifier 111 and further processed by the signal processing circuits 112 to provide an output from the base unit 1.

The phase adjustment information used in receiving signals can also be used in driving transmission signals to provide a maximum signal level at the receiver location. Since the phases of the incoming signals are adjusted to achieve a maximum signal level, the phase adjustments define the position and orientation of the transmitting coil. The same phase adjustments on transmission compensate for this position and orientation. Thus, a single reception coil can be used. According to an embodiment of the invention, the base unit 1 includes three orthogonally positioned coil transducers with phase adjusting circuitry for both reception and transmission. The portable device, therefore, only requires a single coil transducer and can be made smaller in size. As illustrated in FIG. 6, the phase shifters output a phase adjustment to modulator circuits 123 for driving transmission signals. The modulator circuits 123 are shown more fully in FIG. 8. A signal to be transmitted is split and inputted into three mixers 227, 228, 229. Three phase shifters 230, 231, 232 receive a carrier signal and a respective phase adjustment. The phase adjustments are received from the phase shifters 120, 121, 122 in the reception circuitry. The phase shifters provide the phase adjusted carrier signal to the multiplexers 227, 228, 229, where they are multiplied by the signal to be transmitted. The resulting multiplied signals are passed to respective drivers 224, 225, 226 for the three coil transducers 102, 103, 104 for the base unit 1. When the transmitted signal is phase shifted on each of the three coil transducers, the outputs are summed magnetically in transmission to provide a maximum signal at the receiving coil 101.

FIGS. 9 and 10 illustrate another embodiment of the present invention for selective transmission on one of the transducers. As illustrated in FIG. 9, an amplitude detector 201, 202, 203 is connected to each of the transducers 102, 103, 104. The outputs of the amplitude detectors are provided to the modulator circuits 223 for transmission. The modulator circuits 223 are illustrated in FIG. 10. The phase shifters and multipliers operate in the same manner as discussed above. The amplitude information from the amplitude detectors are provided to a coil selection circuit 230. The coil selection circuit selectively activates one of the drivers 224, 225, 226 for the coils. Thus, the coil having the strongest signal can be used for transmission, without having to energize all of the coils. Although FIG. 10 illustrates phase shifting the input signal for all of the coils, when the coils are selectively activated based upon magnitude, the phase shifters can be omitted. Alternatively, if the amplitudes are similar on two or three coils, each of these coils can be activated to increase the transmitted signal. When more than one coil is activated, phase shifting, at least as to polarity, may be needed to avoid cancellation of signals.

FIG. 11 illustrates a second embodiment of the transducer system for the base unit 1. In the transducer 30 of FIG. 6, one of the ferrite rod transducers is replaced with a loop coil transducer 37. A loop coil transducer can replace any or all of the ferrite rod transducers. The loop coil transducer 37 is disposed in the plane of the remaining ferrite rod transducers. This creates a transducer system having a decreased depth. As illustrated in FIG. 2, the three orthogonal transducers can be placed in a corner along the sides of the portable telephone 10. Alternatively, the loop coil transducer 37 could be placed along the back of the portable phone 10, so that it could made thinner.

Additionally, the transmission system can be used for charging the battery 51 of the portable device 2. The base unit 1 includes a battery charger signal generator 52 connected to the transmitter 61. This generator 52 produces a recharging signal which is sent through one of the ferrite rod transducers in the base unit 1 to the ferrite rod transducer 40 of the portable device 2. Since in the telephone embodiment of FIG. 2, the headset 20 and transducer 40 have a known orientation when in the receptacle 19, only one transducer in the portable telephone 10 needs to be energized to inductively transmit the recharging signal. As illustrated in FIG. 3, the wires from the transducer 40 in the portable device 2 are connected to a battery charger 50 which is used to charge the battery 51.

Although the communication system of the present invention has been illustrated in connection with a concha type headset 20 and a cellular or cordless telephone handset 10 as a base unit 1, it is readily adaptable for other types of headsets and uses. The headset can be of the over-the-head type, over-the-ear type, or binaural type. The system can be used as a wireless connection to a conventional desktop telephone. Such a system would operate in the manner discussed above with the cordless handset. Since several such units may be used in close proximity, interference may become more of a problem. Therefore, the system can be designed to operate on various frequencies and can select frequencies for the transmission and reception which are unlikely to have significant interference. Similarly, the system can be used with a computer, either stationary or portable, for voice data entry, sound transmission, and telephone functions. The system can also be used with other types of communication systems, including personal digital assistants (PDAs), cordless phones, PCS and SMR cellular phones, two way (video games), two-way half duplex (walkie-talkies, CBs), or two-way full duplex (phones), one way simplex headphones. When the base unit is stationary and the user is likely to be at certain locations relative to the base unit, fewer transducers may be used in the base unit without encountering mutual inductance nulls. Alternative transducer systems may also be used for generating the inductive fields. Specifically, rather than a single transducer for transmission and reception on different frequencies, separate transducers may be used.

Having thus described one illustrative embodiment of the invention, various alterations, modifications, and improvements will readily occur to those skilled in the art. Such alterations, modifications, and improvements are intended to be within the spirit and scope of the invention. Accordingly, the foregoing description is by way of example only and is not intended as limiting. The invention is limited only as defined in the following claims and equivalent thereto.

What is claimed is:

1. A magnetic inductance communication system, comprising:

a first transmission/reception coil producing a magnetic field including a transmitted signal;

a plurality of second transmission/reception coils having different orientations for receiving the transmitted signal and generating a plurality of received signals;

a summing circuit for combining the plurality of received signals to produce a summed signal;

at least one first phase adjusting circuit for adjusting a phase of at least one respective received signal prior to summing to increase the amplitude of the summed signal; and

a modulator circuit for modulating a signal to be transmitted, wherein the modulator circuit includes:

at least one second phase adjusting circuit receiving a carrier signal and a phase adjustment signal from the at least one first phase adjusting circuit;

a plurality of driving circuits, each driving circuit receiving the signal to be transmitted and a respective output signal from one of the second phase adjusting circuits, for generating a respective driving signal on one of the plurality of second transmission/reception coils to generate a second magnetic field; and

signal processing circuitry connected to the first transmission/reception coil to receive the signal in the second magnetic field.

2. The magnetic inductance communication system of claim 1, wherein said at least one second phase adjusting circuit changes polarity of the carrier signal based upon a polarity of at least one of the received signals.

3. The magnetic inductance communication system of claim 1, wherein said at least one second phase adjusting circuit adjusts the phase of the carrier signal according to phases of each of the received signals.

4. A magnetic inductance communication system comprising:

a first transmission/reception coil producing a magnetic field including a transmitted signal;

a plurality of second transmission/reception coils having different orientations for receiving a transmitted signal and generating a plurality of received signals;

a plurality of amplitude determining circuits corresponding to the plurality of second transmission/reception coils for determining amplitudes of the plurality of received signals;

a modulator circuit for modulating a signal to be transmitted, wherein the modulator circuit includes:

a plurality of driving circuits each driving circuit receiving a carrier signal to be transmitted for generating a respective driving signal on one of the plurality of transmission/reception coils to generate a second magnetic field; and

a selection circuit for activating at least one of the driving circuits based upon the amplitudes of the received signals; and

signal processing circuitry connected to the first transmission/reception coil to receive the signal in the second magnetic field.

5. The magnetic inductance communication system of claim 4, wherein the selection circuit activates one of the driving circuits corresponding to a transmission/reception coil having a greatest amplitude of a received signal.

6. The magnetic inductance communication system of claim 4, wherein the selection circuit activates two of the driving circuits corresponding to a transmission/reception coils having a greatest amplitudes of received signals.

7. The magnetic inductance communication system of claim 6, wherein the modulator further includes at least one phase adjusting circuit receiving the carrier signal and a phase adjustment signal for adjusting the phase of the carrier signal provided to at least one of the two activated driving circuits so that the combined second magnetic field has a maximum value.